Space Weather Technical Forecast

Issued on Tuesday, 04 June 2024 at 12:12 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Moderate solar activity likely with a slight chance of X-class flares. Glancing CME impacts possible early in the period with a chance of G1/G2 Minor or Moderate Geomagnetic Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate during the last 24 hours, with four M-class flares. The largest peaking at 03/1411UTC at M4.8 from AR3695 in the northwest, with the other M-flares originating from AR3697 near south-centre disc. There are currently ten numbered sunspot regions on the visible, with one small unnumbered region in the southeast. AR3697 near south-centre disc remains the most notable spot, the largest and most magnetically complex region, with multiple delta spots. The two regions to its northeast, AR3701 and AR3703, have seen minor growth in recent hours. All remaining regions are either stable or continue to show only minor evolution. There are also currently a number of large and significant filaments of the solar disc, which will be monitored for any potential lift-off.

No Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: Observations by ACE at L1 showed solar wind speeds at background levels initially, between 300-330 km/s, but with a rising trend from around 03/2130 UTC to current slightly elevated levels at around 420-450 km/s. This was due to the glancing blow of a CME, which perhaps left the Sun on 31 May. Density was at average levels initially, but increased to above average, with a peak of 21ppcc at 03/2122 UTC, associated with CME arrival, before returning to below average levels. The Interplanetary Magnetic Field, Bt, was weak initially, 3-6nT, but increased to become Moderate to Strong, with a peak of +18nT at 03/2145 UTC. The north-south component, Bz, also initially weak, +4/-7, became strongly positive (northward) peaking at +18nT, with the CME arrival. Both indices easing back towards weak levels through the remainder of the period. Geomagnetic activity was mostly Quiet (1-2), with a Unsettled to Active interval at 03/2100-0000 UTC (Kp 3-4).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux at GOES18 remained at background levels with no solar radiation storms occurring. High energy electron flux (greater than 2MeV) at GOES16 was at background levels with the associated 24-hour fluence well below the Active threshold. Observed fluence at 04/0000 UTC was 1.23e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is forecast with further M-class flares likely and a slight chance of isolated X-class flares, these mainly from AR3697.

Solar Wind / Geomagnetic Activity: An analysis of a CME associated with a long period M7.3 from AR3697 on the 01 June, suggests a potential glancing impact sometime late on day 1 (04 Jun), but more likely to be early on day 2 (05 Jun). Otherwise largely background solar winds are

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forecast to persist.

Geomagnetic activity is forecast to be mainly Quiet (Kp 2) initially, with a chance of Unsettled or Active intervals (Kp 3-4) due to the lingering impact of a glancing CME from 31 May. The risk of Unsettled or Active conditions increases late day 1 (04 Jun) or more likely into early day 2 (05 Jun), with a chance of G1-G2/Minor-Moderate (Kp5-6) Storm intervals associated with any CME arrival. Any CME influence is likely to gradually wane by day 3 (06 Jun). Becoming mostly Quiet by day 4 (07 Jun).

Energetic Particles / Solar Radiation: High energy proton flux is expected to persist at background, but with a slight chance of rising above the S1/Minor Storm threshold given any notable flares. High energy electron flux is forecast to persist at background, with the associated 24 hour fluence forecast to remain below the Active threshold.

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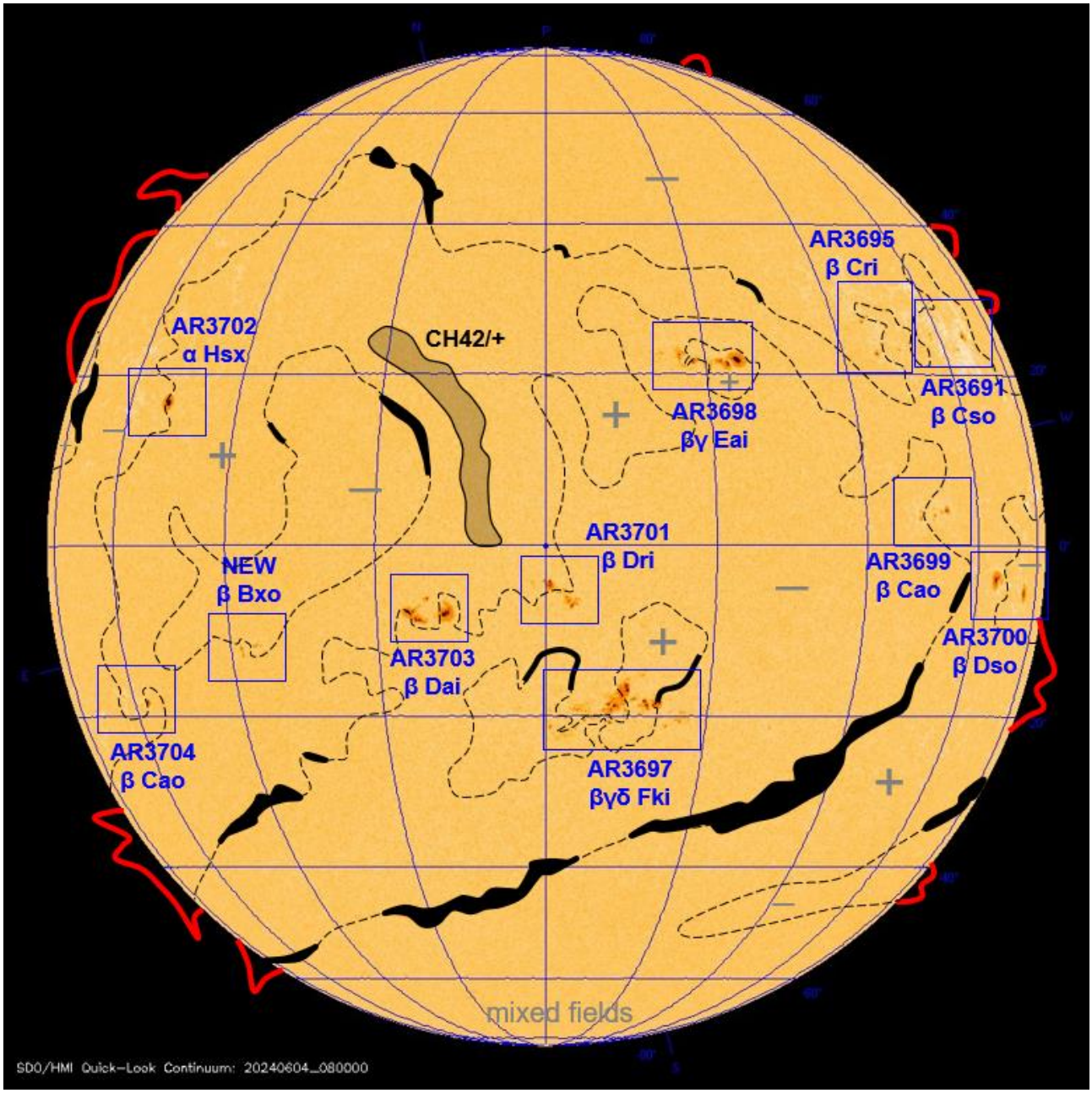
Figure 1. Solar Analysis Valid 04/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The X1.0 flare of AR3697 at 01/1836 UTC was followed by a sympathetic, long period M7.3 flare from the same region, peaking at 01/1940 UTC, with Type II and IV Radio Emissions observed with the second of these flares. A full-halo CME was observed from Earth's frame of reference around the time of the first flare but has been assessed as far-sided, with the second flare resulting in a smaller partial halo CME, potentially Earth-directed but more displaced towards the south and east. Analysis of this second feature suggest the potential for a glancing impact sometime later day 1 (04 Jun), or perhaps more likely early day 2 (05 Jun).

There are also a number of large filaments currently on the Earth-facing disc. These will be closely monitored for any potential Earth-directed eruptions should any of these features lift-off of the solar surface.

Geomagnetic activity is forecast to be mainly Quiet (Kp 2) initially, with a chance of Unsettled or Active intervals (Kp 3-4) due to the lingering impact of a glancing CME from 31 May. The risk of Unsettled or Active conditions increases late day 1 (04 Jun) or more likely into early day 2 (05 Jun), with a chance of G1-G2/Minor-Moderate (Kp5-6) Storm intervals associated with any CME arrival. Any CME influence is likely to gradually wane by day 3 (06 Jun). Becoming mostly Quiet by day 4 (07 Jun).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	50	5	1
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
02/0048	Partial	M7.3 flare	AR3697 SE	700 km/s	05/0000 UTC +-12hrs	Glancing blow

Figure 2: Latest MOSWOC ENLIL Ensemble – showing the potential range of CME arrival times, most likely late on 04 Jun or early 05 Jun. Note, the overestimation of current solar wind speeds which reduces confidence significantly however.

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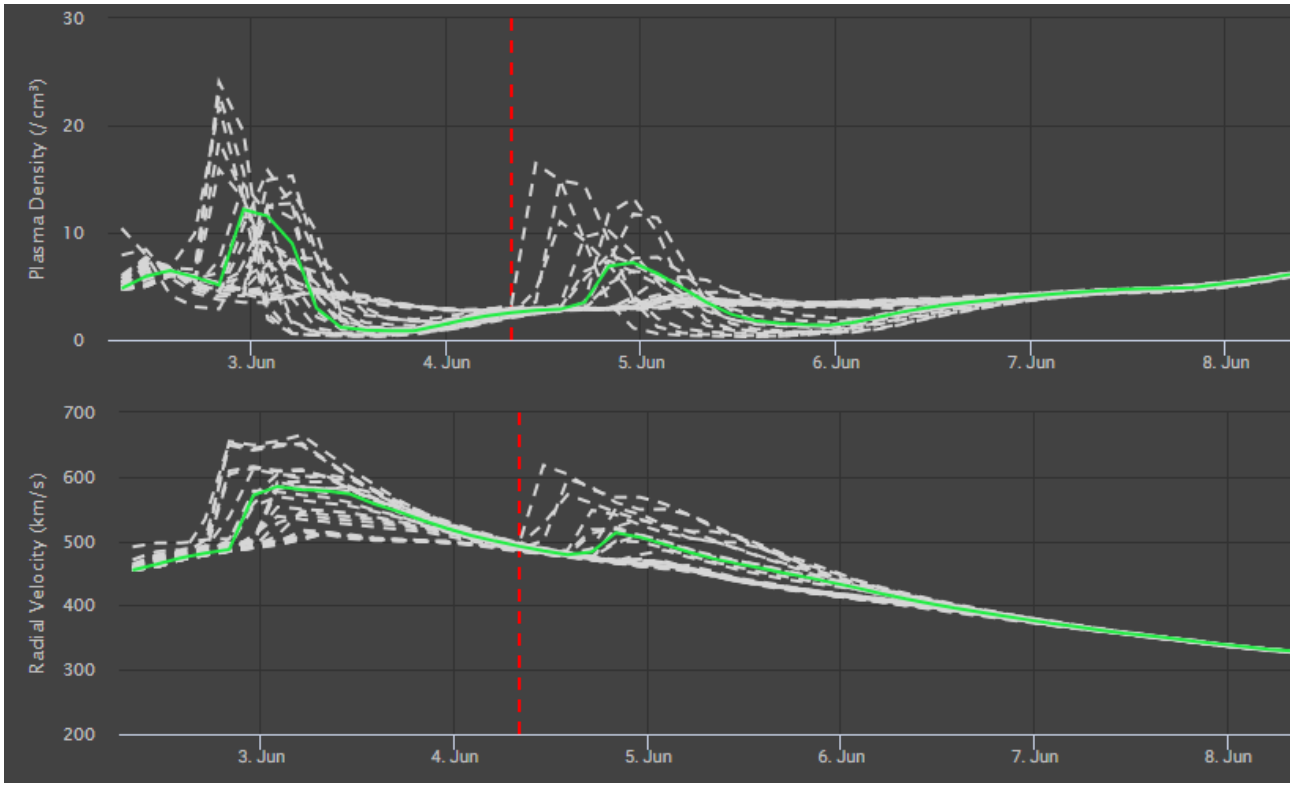

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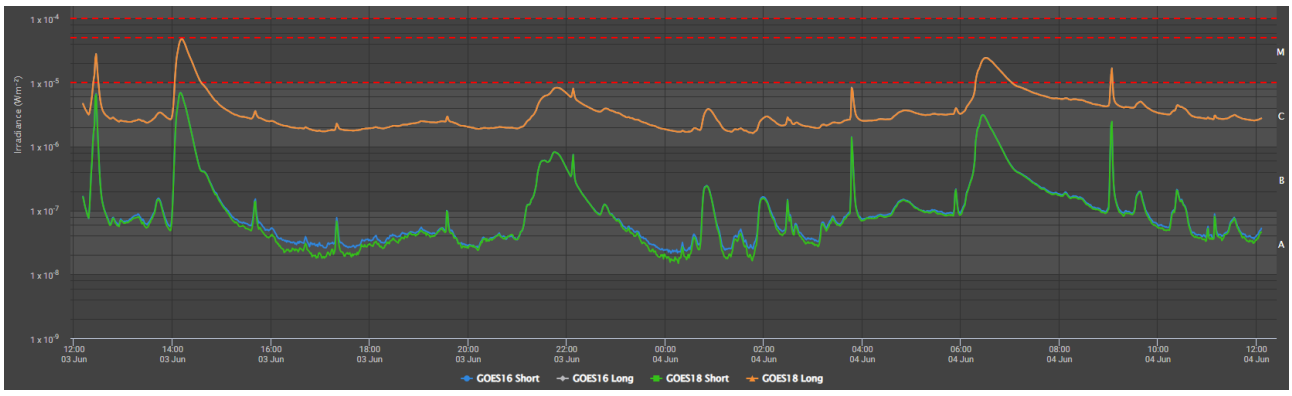
Radio Blackouts - X-Ray Flares:
Solar activity has been Moderate during the last 24 hours, with four M-class flares observed. The largest peaking at 03/1411UTC at M4.8 from AR3695 in the northwest, with the other M-flares originating from AR3697 near south-centre disc. This region brings a likelihood of further M-class flares and a persistent slight chance of isolated X-class flares. The X-class flare risk level increased somewhat due to the history of AR3697, although the region itself continues to show some signs of fragmentation and a slow reduction in areal extent.

Elsewhere on the disc isolated M-class flares are also possible with several moderately sized spots, with the broad plage area of AR3691 and AR3695 contributing to recent flare activity. This area, as well as AR3700 and AR3699 will be approaching the limb by the end of the period but the bulk of current regions will remain visible throughout, and signs in far-side sounding data that potentially significant spots on the currant far side may be approaching the eastern limb by day 3 (06 Jun). The risk of flares is therefore kept constant throughout the period pending further developments, particularly to AR3697 in the near term.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	80	80
Very Active	R3 to R5 X Class	No	20	20	20	20

Figure 3: Latest 24hr GOES18/16 X-Ray trace.



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Solar Radiation Storms - (High Energy Protons):
GOES-18 high energy proton flux is currently at background, with no response observed from the X-flares of AR3697 on 31 May and 01 Jun. This region, however, continues to have the potential for stronger flares, with an steadily improving position for any such flares to eject Earth-directed high energy protons as it transits into the western hemisphere. There is a slight chance of proton flux enhancement occurring and reaching the S1 Minor Storm threshold. Given the potential for stronger flares, it also cannot be completely ruled out that any such proton storm could exceed the strong threshold (S3 Strong radiation storm).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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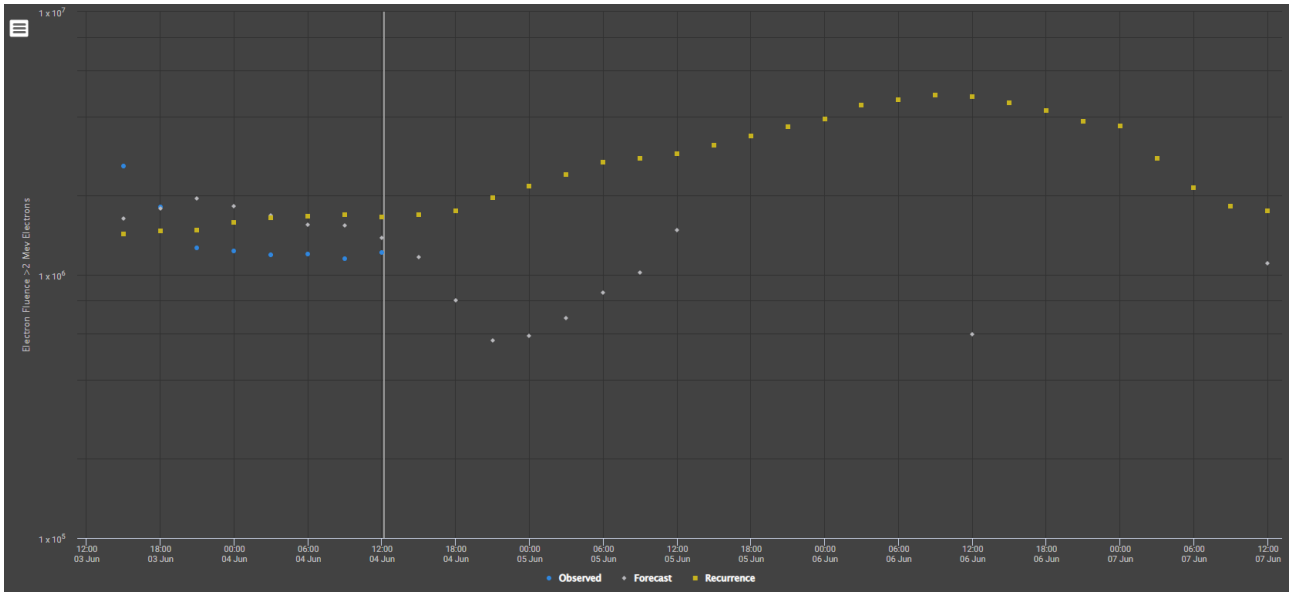
High Energy Electrons Event (≥ 2MeV):
The high energy electron flux, as observed by GOES-16, is expected to persist at mainly background levels, with no notable sources of potential enhancement currently anticipated with any confidence. The associated 24 hour electron fluence is expected to remain well below the Active level, as supported by MOSWOC REFM, which is currently thought to be giving generally good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: Latest MOSWOC REFM model output.



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